FERMILAB-LU-197

Fermilab

April 14, 1993

# Steering Considerations for the 400 MeV Linac

Kevin Junck

The elements needed for beam steering in the simplest of all possible transport lines would consist of one BPM and one dipole correcting magnets. One could calibrate the reading at the BPM with the current through the dipole magnet, and for any measured offset at the BPM, change the current at the dipole magnet to the appropriate value to eliminate the position offset. The same principle applies when scaled up to a more general situation.

Consider N BPMs and M dipole correcting magnets with N > M. The N BPM readings form an array of displacements that we wish to correct. The M dipoles provide an array of angular kicks. The calibration between the BPMs and dipoles is given by a matrix, denoted by T, which is NxM in size. One element of this array, $T_{ij}$, represents the change in position at BPMi due to a change in the angular kick provided by dipolej. The final position of the beam $X_f$ is an array of dimension N and can be described as follows: $X_f = X_o + T\,\Theta$. where $X_o$ is the array of displacements, T is the calibration matrix, and $\Theta$ is the array of dipole angular deflections.

Since we have more than a one-to-one correspondance between BPM's and dipoles, we look at the parameter $S = X_f \times X_f$ and minimize S. To find the minimum of S we take the partial derivative of S with respect to $\Theta_k$ and set that = 0. The result of the matrix math is:

$$T^t\ (X_o + T\,\Theta) = 0.$$

Solving this equation for the array $\Theta$ yields:

$$\Theta = -\,(T^t\ T)^{-1}\ T^t\ X_o.$$

So we measure an array of displacements $X_o$ and calculate a change in the dipole deflections $\Theta$.

This method of beam steering has been tested on the existing linac in the region from Tank 5 to Tank 9. This region has 9 BPMs and 3 dipole correcting magnets for both the horizontal and vertical planes. Preliminary results have indicated that the algorithm works well.